DRAFT REPORT
APPENDIX E-3-3
LABORATORY SCREENING TEST FOR CHLORINATED BENZENES
CIBA-GEIGY SUPERFUND SITE
TOMS RIVER, NEW JERSEY

SUBMITTED BY

Ciba

SUBMITTED TO

EPA
United States Environmental Protection Agency

PREPARED BY

Ciba Specialty Chemicals
Corporate Remediation
Toms River, New Jersey
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1.0 INTRODUCTION

The Ciba-Geigy Superfund Site (Site) located in Toms River, New Jersey has several source areas impacted with chlorinated and non-chlorinated organic chemicals due to past industrial operations, wastewater treatment, and disposal practices. This Site is owned by Ciba Specialty Chemicals (Ciba). Target contaminants that represent significant mass at the Site include chlorobenzene (CB), chlorotoluene (CT), dichlorobenzenes (DCB), trichlorobenzenes (TCB), nitrobenzene, and naphthalene.

The U. S. Environmental Protection Agency's (USEPA) "Final Source Control Remedial Investigation Report" identifies twenty potential contaminant source areas at the Site (UESPA, 1994). Addressing these source areas, collectively known as Operable Unit 2 (OU2), is the goal of the OU2 Feasibility Study. Remedial activities to address the Site-related contamination are regulated under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments Reauthorization Act of 1986 (SARA). The site was placed on the CERCLA National Priorities List (NPL) in 1983.

Technology selection is a significant part of the Feasibility Study. One major contaminant group of significant mass is the chlorinated benzenes that consist of CB, 1,2-DCB, and 1,2,4-TCB. These chlorinated benzenes are part of the target chemicals identified for the Site. The aerobic biodegradation of individual chlorobenzenes (CB, DCBs, and TCBs) is well documented (Howard et al., 1991). However, when these chemicals are present as a mixture, they could alter the relative biodegradation rate of individual chemicals. Because the Site is impacted by a mixture of contaminants, Ciba conducted a screening test to evaluate the effect of multiple contaminants (CB, 1,2-DCB, and 1,2,4-TCB) on the degradation and behavior of individual contaminants in the mixture. Specifically, the degradation of 1,2,4-TCB in the absence and presence of CB and 1,2-DCB was evaluated. The details of the chlorinated benzenes screening test are provided in the Technical Memorandum III submitted to the Agency in September 1998, along with the Composting Treatability Study Work Plan (Ciba, 1998a).

The chlorinated benzenes screening test was started in late June of 1998 and proceeded until February 1999, allowing approximately 8 months of treatment time. This report provides the technical details and results of the chlorinated benzenes screening test.

2.0 SCOPE OF WORK

The chlorinated benzenes screening test was conducted in laboratory microcosms using the Site groundwater and soil. The objectives of the testing are the following:

- Determine the sequence of biodegradation of CB, 1,2-DCB, and 1,2,4-TCB when present as a mixture. Specifically, the degradation of 1,2,4-TCB in the absence and presence of CB and 1,2-DCB was evaluated.

- Measure biodegradation of chlorinated benzenes in both the aqueous and soil phases.

- Monitor important biodegradation parameters such as chloride release and nutrient uptake during contaminant breakdown.

- Determine the lowest practical concentration chlorinated benzenes can reach as a result of biodegradation.

The experimental procedures and results of the testing are discussed in Section 3.0 and Section 4.0, respectively.

3.0 EXPERIMENTAL PROCEDURES

This section describes the experimental design, monitoring parameters, sampling and analytical methods, and soil and groundwater used to conduct the chlorinated benzenes screening test.

3.1 INITIAL CHARACTERIZATION OF GROUNDWATER AND SOIL

Groundwater and soil were collected from the *in situ* Biopilot Cell at the Site for use in the screening test. Prior to use in the test, the groundwater and soil were characterized in duplicate for the parameters listed below:

- pH;
- Ammonia nitrogen;
- Anions (nitrate, nitrite, orthophosphate, sulfate, chloride);
- Cations (sodium, potassium, calcium, magnesium, iron and manganese);
- Total organic carbon (TOC);
- Microbial density; and
- Volatile Organic Compounds (VOC).

These parameters were analyzed to provide baseline information on the status of the nutrients, microbial density, and contamination level. The analytical methods for the above parameters are listed in Table 3.1. The parameters were analyzed either in-house or contracted to an outside analytical laboratory.

3.2 MICROCOSM TESTING

Laboratory-scale testing was conducted to determine the degradation of CB, 1,2-DCB, and 1,2,4-TCB by microorganisms indigenous to the Site. An experiment was conducted in batch microcosms that consisted of 160-ml capacity clean, sterile, glass serum bottles. Approximately 70 mL of groundwater and 25 g of soil were added to each serum bottle. After the addition of groundwater and soil, the bottles were closed with Teflon-lined butyl rubber stoppers and crimped with aluminum seals.

Subsequently, the microcosms were amended with a mixture of chlorinated benzenes (CB, 1,2-DCB, and 1,2,4-TCB) or 1,2,4-TCB alone to establish different treatments. These treatment variations are described in Table 3.2. Microcosms that were amended with the chlorinated benzenes received approximately 50 uL each of CB, 1,2-DCB, and 1,2,4-TCB, while microcosms amended with 1,2,4-TCB alone received approximately 100 uL of 1,2,4-TCB. Appropriate sodium azide-amended control microcosms were maintained to inhibit the biological activity and monitor the abiotic loss, if any. Sodium azide was added to provide a concentration of 700 mg/L. The bottles were incubated in dark at room temperature and mixed periodically on a shaker. Approximately 80-mL air headspace was maintained in the microcosms to provide air required for biodegradation.

3.3 SAMPLING AND ANALYSIS

The testing was carried out for approximately 6 months for the batch of microcosms amended with a mixture of chlorinated benzenes (CB, 1,2-DCB, and 1,2,4-TCB), and for about 8 months for the batch amended with 1,2,4-TCB alone. Microcosms were sampled at 0, 1.6, 3.1, 5.5, and 7.9 months for chlorinated benzenes analysis. Destructive sampling was performed that involved the extraction of entire contents of the bottle. The soil and aqueous fractions were separated and analyzed separately for chlorinated benzenes. Samplings for nutrients were performed at 2.2 and 8 months, while the bacterial count were determined at the start and end of testing. The samples were analyzed for the following parameters:

Liquid Phase:

- pH;
- Ammonia nitrogen;
- Anions (nitrate, nitrite, orthophosphate, sulfate, chloride);
- Total organic carbon; and
- CB, DCBs, and TCBs (VOC by EPA 8260 Method).

Soil Phase:

- Microbial density; and
- CB, DCBs, and TCBs (VOC by EPA 8260 Method).

The methods for the above parameters are listed in Table 3.1. The parameters were analyzed to provide information on the changes in concentration of chlorinated benzenes with time and nature of biological activity (changes in the microbial population, nutrient and pH conditions) during the testing. The parameters were either analyzed in-house or contracted to an outside analytical laboratory.

4.0 RESULTS AND DATA EVALUATION

This section describes the characterization data for groundwater and soil used in the microcosm study and biodegradation results for chlorinated benzenes. In addition, the importance of parameters that impact biodegradation (nutrients and microorganisms) are also discussed.

4.1 GROUNDWATER AND SOIL CHARACTERIZATION

The analytical data on organic and inorganic chemicals in the groundwater and soil are summarized in Table 4.1. The groundwater collected from the Biopilot Cell did not contain significant amount of nitrogen and phosphorus. The Total Kjeldahl Nitrogen (TKN) and orthophosphate were below the method detection limits, while ammonia nitrogen and nitrate nitrogen were low at 0.4 mg/L and 5 mg/L, respectively. The cation (calcium, magnesium, potassium, and sodium) concentration in groundwater was 390 mg/L. The total organic carbon (TOC) concentration in groundwater was 35 mg/L, while in soil it was at 1,545 mg/kg. The chloride level in groundwater was slightly high at 600 mg/L, due to *in-situ* dechlorination activity occurring in the Biopilot Cell. Microbial enumeration revealed the total heterotrophic bacterial count in the range of 10^3 to 10^4 colony forming units (CFUs)/g.

With respect to VOC, the groundwater typically contained chlorinated chemicals from tens of parts per billion (ppb) to hundreds of ppb (Table 4.1). The only compound with concentration in parts per million (ppm) was 1,2,4-TCB (1.33 mg/L)

4.2 MICROCOSM RESULTS

Testing was conducted in microcosms amended with a mixture of CB+1,2-DCB+1,2,4-TCB, and 1,2,4-TCB alone. Specifically, the degradation of 1,2,4-TCB was evaluated in the absence and presence of CB and 1,2-DCB. The degradation was monitored separately in both soil and aqueous fractions. The biodegradation results in soil phase and liquid phase are discussed in Section 4.2.1 and 4.2.2, respectively.

4.2.1 BIODEGRADATION IN THE SOIL PHASE

The results of 1,2,4-TCB biodegradation alone are shown in Table 4.2, while the results of biodegradation of 1,2,4-TCB in the presence of CB and 1,2-DCB are shown in Table 4.3. The results are also summarized in Figure 4.1.

When microcosms contained only 1,2,4-TCB, it was degraded without any appreciable lag time (Figure 4.1). The concentration declined from approximately 2,520 mg/kg to 740 mg/kg within the first sampling point at 1.6 months (Table 4.2). Absence of a significant lag period indicated that the soil sample collected from the Biopilot Cell contained microorganisms acclimatized to degrade 1,2,4-TCB. An extended incubation for about 8 months further reduced 1,2,4-TCB concentration to 2 mg/kg. The degradation was due to microbial action, since poisoned control microcosms (treated with sodium azide) did not reveal any significant loss of 1,2,4-TCB. In the control, 1,2,4-TCB concentration ranged between 2,295 and 3,055 mg/kg during 8 months of treatment (Table 4.2).

However, the presence of CB and 1,2-DCB delayed the degradation of 1,2,4-TCB (Table 4.3; Figure 4.2). When microcosms were amended with a mixture of chlorinated benzenes (CB+1,2-DCB+1,2,4-TCB), the degradation of CB and 1,2-DCB occurred simultaneously, but not 1,2,4-TCB. In the first 3 months of treatment, the concentrations of CB and 1,2-DCB declined from 870 mg/kg to 140 mg/kg and from 1,110 mg/kg to 141 mg/kg, respectively. During the same period, 1,2,4-TCB concentration remained largely unchanged. But, when CB and 1,2-DCB reached low levels (approximately 140 mg/kg), biodegradation of 1,2,4-TCB began to occur. This is evident from a lack of 1,2,4-TCB concentration decline during the first 3 months, and a gradual decline from 1,453 mg/kg to 960 mg/kg in the next 2.5 months (Table 4.3).

An extended treatment time beyond 5.5 months is expected to further decrease 1,2,4-TCB concentration from biodegradation. These results indicated that all chlorinated benzenes tested were biodegradable, however, the presence of lower chlorinated chemicals (CB and 1,2-DCB) precluded the degradation of higher chlorinated benzenes (1,2,4-TCB).

4.2.1 BIODEGRADATION IN THE AQUEOUS PHASE

In addition to the soil, the aqueous phase was analyzed for chlorinated benzenes. Table 4.2 shows the results of 1,2,4-TCB biodegradation, while Table 4.3 shows the results of biodegradation of 1,2,4-TCB in the presence of CB and 1,2-DCB. The results are illustrated in Figure 4.2.

From literature, it is known that CB is more water-soluble than 1,2-DCB, while 1,2-DCB is more water-soluble than 1,2,4-TCB. At start, the solubility property governed the amount of chlorobenzenes recovered from the aqueous phase (CB was recovered in greater quantities than DCB and TCB). The amount of CB, 1,2-DCB, and 1,2,4-TCB recovered at time zero was approximately 123,000 ug/L, 41,000 u/L, and 11,000 ug/L, respectively (Table 4.3).

The sequence of biodegradation of the three chlorobenzenes (present as a mixture) in aqueous phase almost followed the similar pattern as observed with the soil phase (Figure 4.2). Biodegradation of 1,2,4-TCB, when present alone, was degraded rapidly and the concentration declined from approximately 21,200 ug/L to 95 ug/L in 8 months (Table 4.2). Although biodegradation occurred without a lag time in soil, 1,2,4-TCB concentration did not decline in the aqueous phase during the first 1.6 months. This trend suggested that biodegradation might be occurring, but not evident because of a greater desorption rate and less biodegradation rate initially. However, after 1.6 months, 1,2,4-TCB concentration declined sharply (from 27,540 ug/L to 95 ug/L), indicating a greater biodegradation rate and less desorption rate.

Like in the soil phase, presence of CB and 1,2-DCB precluded biodegradation of 1,2,4-TCB in the aqueous phase. In 5.5 months, the concentration of CB declined from approximately 121,000 ug/L to 700 ug/L, while 1,2-DCB declined from approximately 40,000 ug/L to 300 ug/L (Table 4.3). The concentration reduction of CB, and 1,2-DCB was due to microbial action, since similar losses were not observed in the poisoned control microcosms. However, during the same period, 1,2,4-TCB concentration progressively increased from about 10,300 ug/L to 31,300 ug/L. The increase is due to increased solubility and desorption of 1,2,4-TCB with time. The increase in 1,2,4-TCB concentration and a decrease in CB and 1,2-DCB concentration follows the non-aqueous phase liquid (NAPL) dissolution model (Ciba, 1998b). According to this model, the solubility limit of the

chemicals changes as the composition of NAPL changes. Thus, decrease in the concentration of water-soluble chemicals, such as CB and 1,2-DCB, increased the concentration of less soluble 1,2,4-TCB. Further treatment greater than 5.5 months is likely to cause decline in 1,2,4-TCB concentration due to biodegradation.

4.3 NUTRIENT AND MICROBIAL CHARACTERIZATION

The nutrient characterization included monitoring of pH, nutrient, chloride, sulfate, and microorganisms during treatment. The results are presented in Tables 4.4 and 4.5. The optimal pH for bioremediation is generally accepted to be within the range of 6 to 8. A pH outside this range may reduce microbial metabolism and biodegradation. The pH remained near neutral during 8 months of treatment.

Nutrients (ammonia nitrogen, nitrate nitrogen, orthophosphate, and TOC) are necessary to support microbial degradation. Nutrient addition will become necessary for successful bioremediation when their concentrations are severely limited. The groundwater used in the testing was limiting in nutrient. Nutrient in the form ammonium phosphate and urea were added to the microcosms to provide a concentration of 30 mg/L of nitrogen and 27 mg/L of phosphorus. Ammonia-nitrogen was generally high in the control and low in active microcosms, revealing the utilization of nitrogen by microorganisms during biodegradation. At the end of treatment, ammonia nitrogen ranged between 28.8 and 34.1 mg/L in the control treatments, compared to between 21.4 and 22.2 mg/L in the active treatments (Table 4.4). A similar trend was observed with TOC.

Chloride is an expected product of chlorinated benzenes biodegradation. An increase in chloride concentration will indicate biodegradation. The groundwater used in the test contained 600 mg/L of background chloride and the concentration increased to 1,864 mg/L after 8 months of treatment in microcosms amended with 1,2,4-TCB (Table 4.4). Subtracting the background value, the mass balance calculation indicated that the chloride released accounted for approximately 85 percent of 1,2,4-TCB degradation. Similarly, a chloride increase was observed in microcosms amended with a mixture of CB, 1,2-DCB, and 1,2,4-TCB, and mass balance indicated that chloride accounted greater than 50 percent of the mass. No increase in chloride concentration was observed in poisoned control, indicating lack of microbial degradation in these microcosms.

The concentration of sulfate was largely unaffected during treatment (Table 4.4). A decline in sulfate concentration would indicate anaerobic conditions during the treatment, since sulfate can serve as an electron acceptor and substitute for oxygen.

Microbial population (heterotrophic bacteria) were grown on the Tryptic-Soy agar medium and enumerated by the spread plate technique. Microbial population was enumerated at the start and after completion of the treatment. The results are presented in Table 4.5. The soil collected from the Biopilot Cell exhibited total heterotrophic bacteria count in the range of 10^4 to 10^5 CFUs/g. The bacterial count increased only marginally at the end of microcosm testing. Although no degradation was observed in sodium azide-treated controls (evident from no chloride increase), the bacterial population was recovered at 10^3 CFUs/g.

5.0 SUMMARY

The chlorinated benzenes screening testing was conducted in laboratory microcosms using the Site groundwater and soil for a period of 8 months. The microcosm results are summarized below:

- The soil microorganisms indigenous to Site were capable of degrading the chlorinated benzenes tested (CB, 1,2-DCB, and 1,2,4-TCB).

- The degradation of CB and 1,2-DCB occurred simultaneously, followed by 1,2,4-TCB biodegradation.

- The presence of less chlorinated chemicals precluded 1,2,4-TCB biodegradation. This was evident from the lag time of greater than 3 months for 1,2,4-TCB degradation in the presence of CB and 1,2-DCB, compared to little or no lag time in their absence.

- In soil, the concentration of CB, 1,2-DCB, and 1,2,4-TCB decreased from approximately 850-2,500 ppm to less than 3 ppm after 8 months of treatment.

- In groundwater, the 1,2,4-TCB concentration decreased from approximately 21,000 ppb to 95 ppb after 8 months treatment. For CB and 1,2-DCB, the concentrations decreased from approximately 40,000 ppb to 300 ppb and from 121,000 ppb to 700 ppb, respectively, after 5.5 months of treatment. With additional treatment, it is likely that CB and 1,2-DCB would also decline to less than 100 ppb as observed for 1,2,4-TCB (declined to 95 ppb in 8 months).

The above results confirm that chlorinated benzenes, which belong to the list of target chemicals, can be biodegraded by microorganisms native to the Site, and bioremediation can be an option for these contaminants. Although all chlorinated benzenes tested were biodegraded, samples containing 1,2,4-TCB and other co-contaminants would require a longer treatment time.

6.0 REFERENCES

Ciba Specialty Chemicals Corporation, 1998a. "Composting Treatability Study Work Plan, Aerobic Composting of Toms River Soils and Selected Non-Soil Wastes", Toms River, New Jersey.

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Standard Methods for the Examination of Water and Wastewater, 1992, 18th Ed. Greenberg, A. E., Clesceri, L. S., Eaton, A. D., American Public Health Association, American Water Works Association, Water Environment Federation, Washington, D. C.

USEPA, 1994. "Final Source Control Remedial Investigation Report: Ciba-Geigy Site, Toms River, New Jersey".

TABLE 3.1
Analytical Parameters and Methods
Chlorinated Benzenes Screening Test
Ciba-Geigy Superfund Site
Toms River, New Jersey

Analytical Parameters	Analytical Methods [1]
pH	EPA Method 150.1
Ammonia nitrogen	EPA Method 350.2
Total Kjeldahl nitrogen	EPA Method 351.2
Anions (nitrate, nitrite, orthophosphate, sulfate)	EPA Modified Method 300.0
Cations (sodium, potassium, calcium, magnesium, iron, and manganese)	Standard Methods Method 3500 [2]
Total organic carbon	EPA Method 450.1
Microbial density	Standard Methods Method 9215
VOC	EPA Method 8260

Notes:
(1) The analytical parameters will be analyzed by the methods listed in the table or by an equivalent method.
(2) Standard Methods for the Examination of Water and Wastewater, 1992, 18th Edition.

TABLE 3.2
Treatment Description for the Microcosm Study
Chlorinated Benzenes Screening Test
Ciba-Geigy Superfund Site
Toms River, New Jersey

Treatment Number	Treatment Type	Amendment with Chlorobenzenes
1	Control [1]	Microcosms were amended with a mixture of CB, 1,2-DCB, and 1,2,4-TCB
2	Active	Microcosms were amended with a mixture of CB, 1,2-DCB, and 1,2,4-TCB
3	Control	Microcosms were amended with 1,2,4-TCB
4	Active	Microcosms were amended with 1,2,4-TCB

Notes:
(1) Control microcosms were treated with sodium azide to inhibit the microbial activity.

TABLE 4.1

Initial Characterization of the Groundwater and Soil [1]
Chlorinated Benzenes Screening Test
Ciba-Geigy Superfund Site
Toms River, New Jersey

VOC[2]	Groundwater (ug/L)
Trichloroethene	26
Tetrachloroethane	19
Chlorobenzene	46
1,1,2,2-Tetrachloroethane	116
2-Chlorotoluene	262
4-Chlorotoluene	20
1,3-Dichlorobenzene	29
1,4-Dichlorobenzene	91
1,2-Dichlorobenzene	396
1,2,4-Trichlorobenzene	1,333
1,2,3-Trichlorobenzene	46

Analytical Parameters	Soil (mg/kg)	Groundwater (mg/L)
Calcium	775	385
Iron	4,525	9
Magnesium	118	30
Manganese	9	0.1
Potassium	93	42
Sodium	68	201
Total Organic Carbon	1,545	35
Total Kjeldahl Nirogen	ND(<150)	ND(<0.85)
Ammonia-Nitrogen	ND(<5.2)	0.4
Chloride	70	600
Nitrite-Nitrogen	ND(<0.8)	ND(<0.4)
Nitrate-Nitrogen	3	5
Ortho-phosphate	ND(<3.5)	ND(<1.8)
Sulfate	34	270

Notes:
(1) Groundwater and soil were collected from the Biopilot Cell at the Site.
(2) VOC with concentration greater than 5 ug/L are listed.
ND - Not detected (below detection limit).

TABLE 4.2
Aerobic Biodegradation of 1,2,4-TCB in Soil Slurry Microcosms
Chlorinated Benzenes Screening Test
Ciba-Geigy Superfund Site
Toms River, New Jersey

Chemical	Treatment	Month 0	Month 1.6	Month 3.1	Month 5.5	Month 7.9
Aqueous Phase (ug/L)						
1,2,4-Trichlorobenzene	Control [1]	42,344	37,116	50,799	81,403	17,572
	Active	21,231	27,540	14,324	646	95
Soil (mg/kg)						
1,2,4-Trichlorobenzene	Control	2,596	2,298	3,055	2,676	2,295
	Active	2,519	740	370	12	2

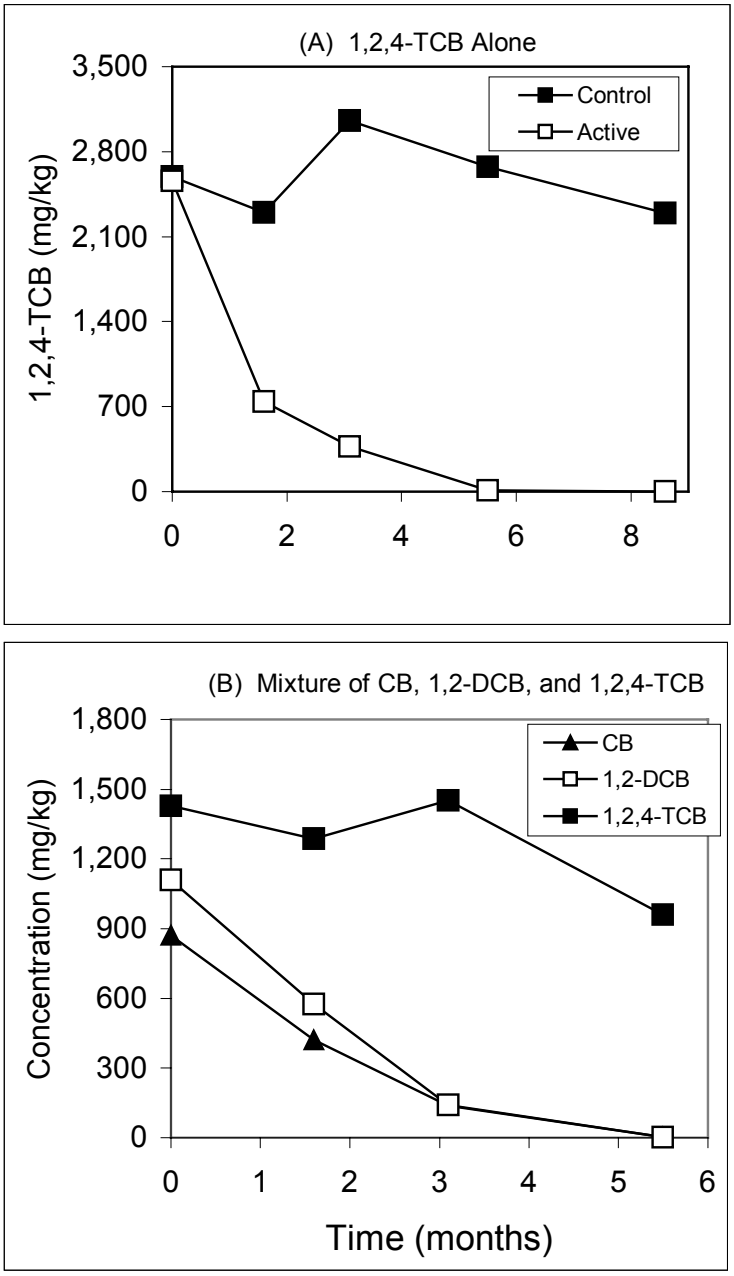
Notes:
(1) Control microcosms were treated with sodium azide to inhibit microbial activity.

TABLE 4.3
Aerobic Biodegradation of CB, 1,2-DCB, and 1,2,4-TCB Mixture in Soil Slurry Microcosms
Chlorinated Benzenes Screening Test
Ciba-Geigy Superfund Site
Toms River, New Jersey

Chemicals	Treatment	Month 0	Month 1.6	Month 3.1	Month 5.5
Aqueous Phase (ug/L)					
Chlorobenzene	Control [1]	125,395	126,296	113,452	96,390
	Active	120,540	89,645	34,770	683
1,2-Dichlorobenzene	Control	40,936	51,304	41,991	45,787
	Active	39,780	33,031	9,174	294
1,2,4-Trichlorobenzene	Control	11,928	16,592	14,058	21,658
	Active	10,275	17,375	26,123	31,296
Soil Phase (mg/kg)					
Chlorobenzene	Control	834	699	916	722
	Active	870	420	140	2.51
1,2-Dichlorobenzene	Control	1,133	1,045	1,330	1,155
	Active	1,110	574	141	2.32
1,2,4-Trichlorobenzene	Control	1,443	1,315	1,898	1,643
	Active	1,429	1,288	1,453	960

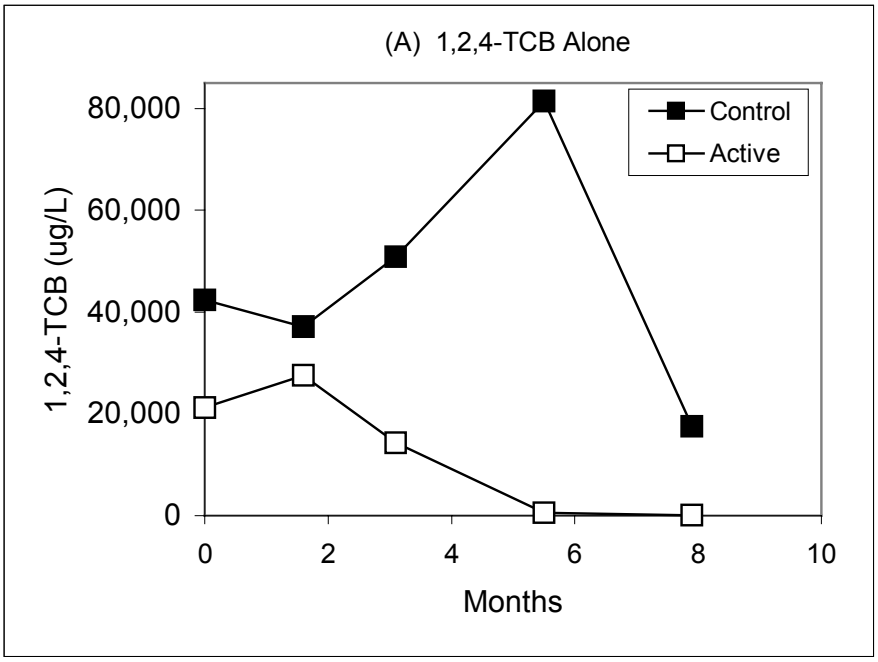
Notes:
(1) Control microcosms were treated with sodium azide to inhibit microbial activity.

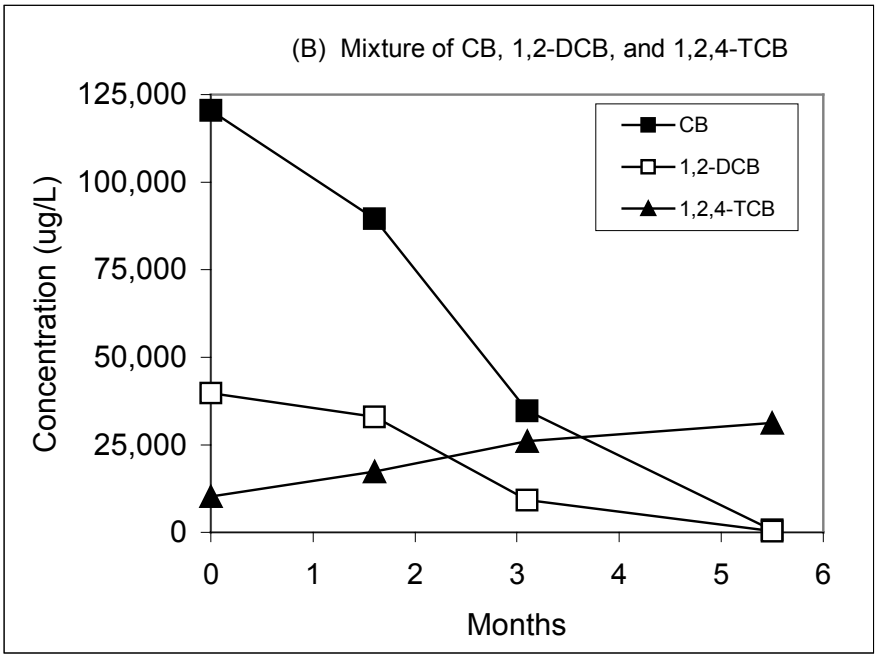
FIGURE 4.1
Biodegradation of 1,2,4-TCB in the (A) Absence and (B) Presence of CB and 1,2-DCB in the Soil Phase
Chlorinated Benzenes Screening Test
Ciba-Geigy Superfund Site, Toms River, New Jersey



Notes:
Control - Microcosms were treated with sodium azide to inhibit the microbial activity

FIGURE 4.2
Biodegradation of 1,2,4-TCB in the (A) Absence and (B) Presence of CB and 1,2-DCB in the Aqueous Phase
Chlorinated Benzenes Screening Test
Ciba-Geigy Superfund Site
Toms River, New Jersey





Notes:
Control - Microcosms treated with sodium azide to inhibit the microbial activity.

TABLE 4.4
Changes in Nutrient, Chloride, and Sulfate During the Microcosm Study
Chlorinated Benzenes Screening Test
Ciba-Geigy Superfund Site
Toms River, New Jersey

Concentration (mg/L)	Microcosms amended with 1,2,4-TCB Alone					
	Control [(1)]			Active		
	Initial	Month 2.2	Month 8	Initial	Month 2.2	Month 8
Chloride	600	630	576	600	1,480	1,864
Sulfate	270	277	298	270	270	307
TOC	34.6	90	63.5	34.6	67	51.3
Nitrate	4.6	ND (<80)	NA*	4.6	ND (<0.4)	ND(<0.012)
Nitrite	ND(<0.4)	ND (<20)	NA	ND(<0.4)	ND (<40)	NA
Ortho-phosphate	ND(<1.8)	3.5	ND(<0.036)	ND(<1.8)	11.5	ND(<0.036)
Ammonia	0.41	19.2	28.8	0.41	NA	22.2
Concentration (mg/L)	Microcosms amended with a Mixture of CB, 1,2-DCB, and 1,2,4-TCB					
	Control			Active		
	Initial	Month 2.2	Month 8	Initial	Month 2.2	Month 8
Chloride	600	600	596	600	1,010	1,116
Sulfate	270	263	290	270	280	301
TOC	34.6	96	70	34.6	67	62.2
Nitrate	4.6	ND (<80)	NA*	4.6	ND (<0.8)	ND(<0.012)
Nitrite	ND(<0.4)	ND (<20)	NA	ND(<0.4)	ND (<20)	NA
Ortho-phosphate	ND(<1.8)	3.8	ND(<0.036)	ND(<1.8)	3.6	ND(<0.036)
Ammonia	0.41	24.6	34.1	0.41	NA	21.4

Notes:
* Interference
NA - Not analyzed.
ND - Not detected (below detection limit).
TOC - Total organic carbon.
(1) Control microcosms were treated with sodium azide to inhibit the microbial activity.

TABLE 4.5
Microbial Enumeration During the Microcosm Study
Chlorinated Benzenes Screening Test
Ciba-Geigy Superfund Site
Toms River, New Jersey

Microcosm Description	Treatment	Start of Microcosm Testing (CFUs/g)	End of Microcosm Testing (CFUs/g)
Microcosm amended with 1,2,4-TCB	Control (1)	12×10^3	36×10^3
	Active	42×10^4	22×10^5
Microcosm amended with a Mixture of CB, 1,2-DCB, and 1,2,4-TCB	Control	12×10^3	6×10^4
	Active	18×10^5	$>30 \times 10^5$

Notes:
(1) Control microcosms were treated with sodium azide to inhibit microbial activity.
CFUs - Colony Forming Units. The count represents total heterotrophic bacteria.